• BULGUR WAFER AND ADJUNCTS FOR FALLOUT SHELTER RATIONS •OCD• WORK UNIT No. 1311A • WRRL•ARS•USDA• NOVEMBER 1967

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BULGUR WAFER AND ADJUNCTS

FOR FALLOUT SHELTER RATIONS

A report of research conducted July 1966 - June 1967

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SUMMARY

Surveillance of the food stocks in fallout shelters must be practiced to assure the quality of the food at time of need. Monitoring of stocks would be aided by a simple objective test which was correlated with organoleptic quality.

We have continued to search for volatile components from puffed bulgur which could be possibly useful in this regard. Headspace gas samples from stored puffed bulgur were analyzed by a gas-liquid chromatographic (GLC) technique which classified the aroma of observed peaks. For this study, the GLC effluent stream was split; one part was smelled by a trained observer and one part was passed through a detector and recorded on a strip chart. Using the headspace gas directly, this technique showed five GLC peaks which were described as rancid with boiling points lower than hexanal. When rancid-bulgur was steam distilled and the distillate extracted with pentane, the concentrated pentane extract showed four GLC peaks which were described as rancid with boiling points slightly above hexanal. These nine components have not been previously observed and may in large measure be responsible for rancid odor.

Analysis of the fatty acid components of bulgur and puffed bulgur and comparison with data from other workers on whole wheat flour show little difference in composition. Consequently processing appears to have little influence on the fatty acids present in the neutral lipids.

An accelerated storage test on puffed bulgur and periodic simultaneous panel evaluation and headspace analysis for volatile components provided the following relationships. Hexanal content would appear to be a reasonable indication of odor change. However, previous work showed hexanal content was not over more extended storage periods.

Carbon dioxide, methane, and carbon monoxide content did not provide a useful index of product stability. The carbon monoxide results are contrary to findings under the wafer storage study at Oregon State University. Pentane content of the headspace gas may be a useful test for surveillance.

Oxygen uptake of puffed bulgur was measured and the consumption of oxygen related to the time of appearance of carbon dioxide, carbon monoxide, pentane and hexanal.

Changes in flavor scores of bulgur wafers have been evaluated to reflect how quality is influenced by several experimental variables. The slope (change of hedonic flavor score with time) of the regression line for the reference sample (pressure-cooked bulgur, malt sirup binder, and nitrogen pack) is not significantly different from zero. The overall average for this sample is 6.15 (6.0 = like slightly, 7.0 = like moderately). All reference-preference scores have been adjusted to correspond to this hedonic score by assigning this overall average value as the zero time intercept for all samples. The regression line for nitrogen-packed samples stored at 40°, 70°, and 100°F has a very small negative slope significantly different from zero. The regression line for air-packed samples stored at 40°F also has a very small negative slope significantly different from zero. It is most important that the slope of the regression line for nitrogen-packed samples stored at 100°F is not significantly different from the slope of the regression line for air-packed samples stored at 40°F. This is a strong argument for nitrogen-packing.

Samples of air-packed wafers stored at 70° and 100°F show a greater change in flavor score with time and the relationship is non linear However, the average flavor score for any storage time has not fallen below 4.5 (5.0 = neither like nor dislike, 4.0 = dislike slightly).

The other variables, binder and method of cooking, have less influence on flavor score than packaging atmosphere.

Of the objective tests being investigated for possible use in surveillance testing of the wafers, carbon monoxide content of the headspace gas appears to be the most promising. Correlation between this analysis and taste panel scores (since 22 months of storage when the carbon monoxide measurement was started) for all formulations at all temperatures are significant at the 1% level.

Results of panel evaluations after 42 months' storage of twelve selected adjuncts indicate that nitrogen packing provides a protective action considering all test temperatures for apple topping, raspberry jelly, curry sauce, Oriental sauce and paprika gravy. For all other adjuncts except strawberry spread considering all test temperatures there is no significant difference. Strawberry spread samples with air packaging are preferred to those with nitrogen packaging. Among the seven adjuncts for which in-package desiccant (IPD) is a treatment variable, samples with IPD scored higher for all except beef soup which showed no significant difference.

Expert panel evaluations of the adjuncts before, during, and after preparation reveal that certain treatments of some of the adjuncts are not performing well. Also can corrosion has reached serious proportions for some treatments for a few adjuncts. In general, flavor scores are staying up for some combination of variables even at higher temperature storage so that ease of preparation or can corrosion may be the first limiting factor for some adjuncts.

Carbon monoxide content of the headspace gas, from the adjunct samples may be related to flavor score. Samples packed under nitrogen show very low carbon monoxide levels. Samples packed in air without desiccant in general show a high level of carbon monoxide. IPD reduces the carbon monoxide level. In almost all cases, increasing storage temperature for air-packed samples without desiccant causes increases in carbon monoxide content.

BULGUR WAFER AND ADJUNCTS FOR FALLOUT SHELTER RATIONS

SECTION 1

DEVELOPMENT OF NEW STABILITY EVALUATION METHODS

Work continued on the development of reliable objective measurements, that correlate with expert odor panel appraisal, for use in surveillance testing of stored bulgur wafers. The premise that unsaturated fatty acids of wheat lipids contained in the bulgur wafers are the components most likely to limit wafer shelf life continues to guide the research.

Efforts have been continued to identify the volatile components of puffed bulgur. A new technique has been utilized to classify odoriferous, volatile components from stored puffed bulgur by correlating chromatographic measurements with evaluations of a trained observer.

Also, studies were made of the correlation of off-flavor development and levels of hexanal, carbon dioxide, carbon monoxide, and pentane in puffed bulgur under accelerated storage conditions.

In addition, the oxygen uptake of puffed bulgur was measured and the consumption of oxygen related to the time of appearance of carbon dioxide, carbon monoxide, pentane, and hexanal.

Components of Bulgur

Volatiles

Headspace gas samples from the stored canned puffed bulgur used in the accelerated storage study (see Acceleration of Rancidity, this report) were analyzed by a new technique. The technique is one that had been applied to fruit volatiles at the Western Regional Research Laboratory, U.S. Department of Agriculture [Correlation of Sensory and Gas-liquid Chromatographic Measurements of Apple Volatiles, Guadagni, D. G., Okano, S., Buttery, Ron G., and Burr, H. K. Food Technology 20, 166-169 (1966) and Identification and Organoleptic Evaluation of Compounds in Delicious Apple

Essence, Flath, R. A., Black, D. R., Guadagni, D. G., McFadden, W. H., and Schultz, T. H. Agriculture and Food Chemistry 15, 29-35 (1967)]. The sample of headspace gas was passed through a gas-liquid chromatographic column. The discharge from the column was split. One portion was passed through a detector and peaks recorded on a strip chart. The other portion was smelled by a trained observer who described the odor for each peak.

Details of the chromatographic set-up are as follows: Column, 500 ft. of 0.03-inch tubing coated with General Electric SF 96-50 silicone oil containing 1% Igepal; temperature, 65°C for 15 minutes then increased either 1°C per minute or 2°C per minute until 165°C reached when the experiment is discontinued; detector, flame ionization; effluent split, 50%/50% between detector and trained observer.

The headspace gas from the test samples of puffed bulgur showed five peaks which were described as rancid in the region below hexanal (i.e. with lower boiling points). While the odor panel could detect the difference between a sample of puffed bulgur stored in oxygen at 90°F and a control sample, the change was described as loss of freshness rather than development of rancidity. The headspace gas from above the control sample showed no peaks described as rancid in this same region on the strip chart.

A sample of truly rancid smelling puffed bulgur from another source was treated in an apparatus which simultaneously steam distilled the bulgur and extracted the steam distillate with pentane. The pentane extract was concentrated and the concentrate put through the same gas-liquid chromatographic set-up. In this case four chromatographic peaks were characterized as having rancid-type odors by the expert observer, but these were all above hexanal (i.e. with higher boiling points). Probably the lower boiling components observed in the headspace gas had been lost in the steam distillation-pentane extraction-concentration process.

The absence of the higher boiling components with rancid-type odors in the chromatogram of the headspace gas is understandable since they would

probably occur at less than detectable concentrations because of their low vapor pressures.

This new gas-liquid chromatographic technique has revealed some components not previously observed which may in large measure be responsible for rancid odor. However, further work would be required to identify and evaluate them for their contribution to the rancid odor of puffed bulgur.

Fatty Acids

The lipids of bulgur were obtained by hexane extraction and converted to the free fatty acids by acid hydrolysis. Methyl esters were obtained through reaction with diazomethane. These esters were analyzed by gas-liquid chromatography and the concentration of each ester was estimated by comparing its peak area with the area obtained from known amounts of authentic standards.

The following table summarizes the concentrations of the principal fatty acids in bulgur and puffed bulgur. Data from Nelson and coworkers for whole wheat flour are included for purpose of comparison [J. H. Nelson, R. L. Glass, and W. L. Geddes, Cereal Chem. 40, 343 (1963)].

	Flour	Bulgur	Puffed bulgur
Palmitic	16.7%	18.3%	15.5%
Stearic	0.3	1.4	0.9
Oleic	16.5	20.3	17.4
Linoleic	59.0	55.6	62.0
Linolenic	4.3	4.3	3.5

These data show little difference in the concentration of linoleic and oleic acids in all three products and consequently processing appears to have little influence on the quantities of these acids present in the neutral lipids (hexane-soluble fraction).

Acceleration of Rancidity

Storage of puffed bulgur

An accelerated storage study on puffed bulgur has proceeded for 23 weeks. Test samples were stored under oxygen at 90°F; control samples were stored under nitrogen at room temperature. Periodically samples were evaluated for odor by a trained panel and headspace gas samples were analyzed for carbon dioxide, carbon monoxide, saturated hydrocarbons (C_1-C_5), and hexanal by gas-liquid chromatography.

The growth curve for hexanal roughly parallels the number of correct panel judgments in discriminating between controls and test samples in a triangle test since the 4th week (Figures 1.1 and 1.2). On the 18 week 94% of the panel made correct identifications. Thus, hexanal would appear to be a reasonable indicator for the observed odor change (which was not characterized as rancidity). However, previous work showed that hexanal concentration did not indicate rancidity development over a more extended period. To develop more information on this point a new control, puffed bulgur judged rancid, has been used since the 18th week (for this reason data are not plotted). A panel of expert judges has been able to differentiate significantly between the test samples and the rancid reference sample, but the number of correct judgments is decreasing with storage time. This trend appears to indicate that the oxidative off-flavor of the test sample is approaching that of the new control.

Carbon dioxide appeared after one day of storage but its level has not increased significantly. Methane concentration increased up to 4 weeks but then leveled off. Neither of these compounds is suitable as an index of rancidification in bulgur wafers.

Carbon monoxide increased up to 18 weeks but leveled off at that time (Figure 1.3). Although the increase in carbon monoxide level parallels the early oxidative off-flavor change it appears not to be a useful index of long term stability. This is contrary to the findings under the

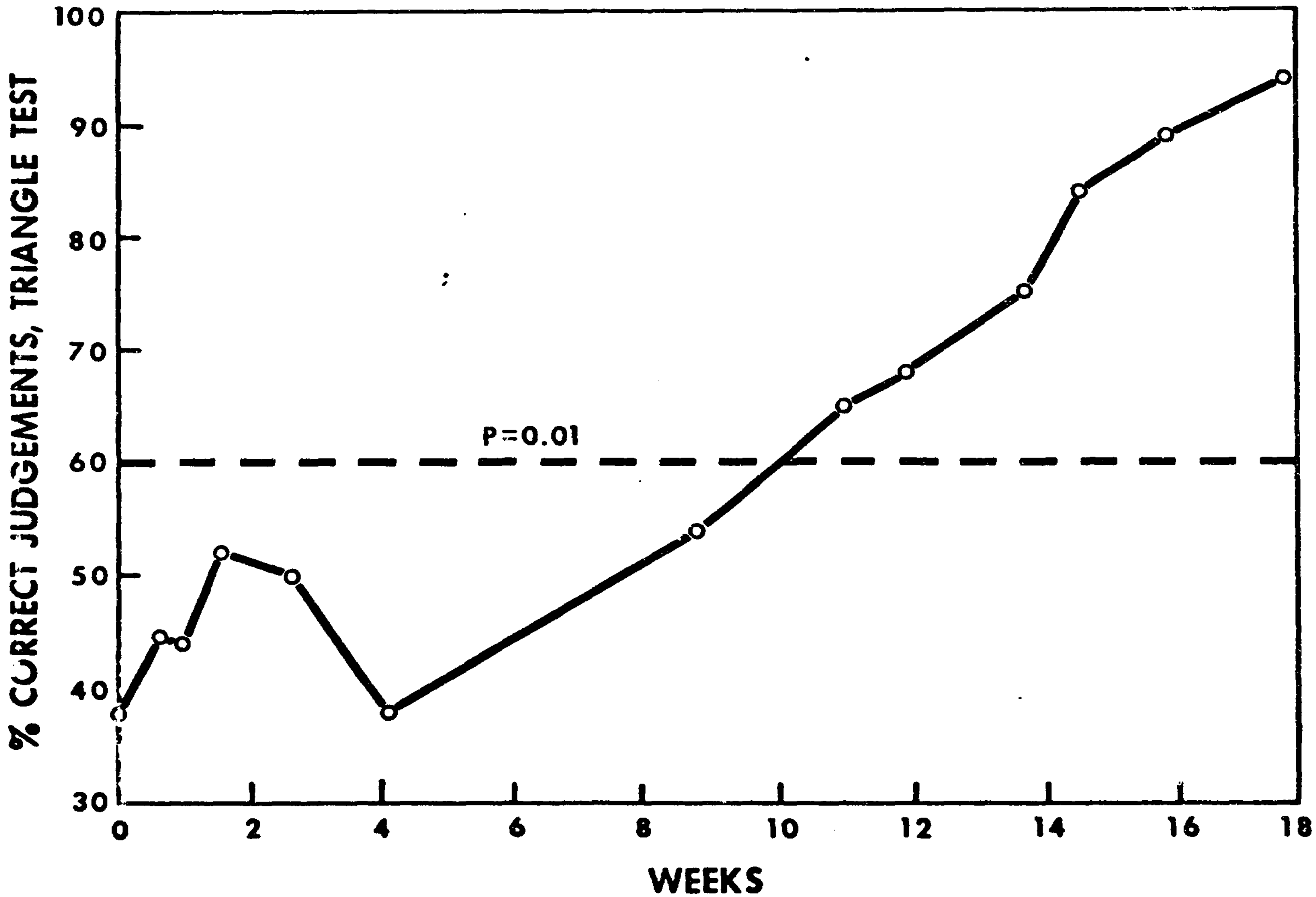

Figure 1.1 PANEL EVALUATION OF PUFFED GROUND BULGUR STORED AT 90°F IN OXYGEN

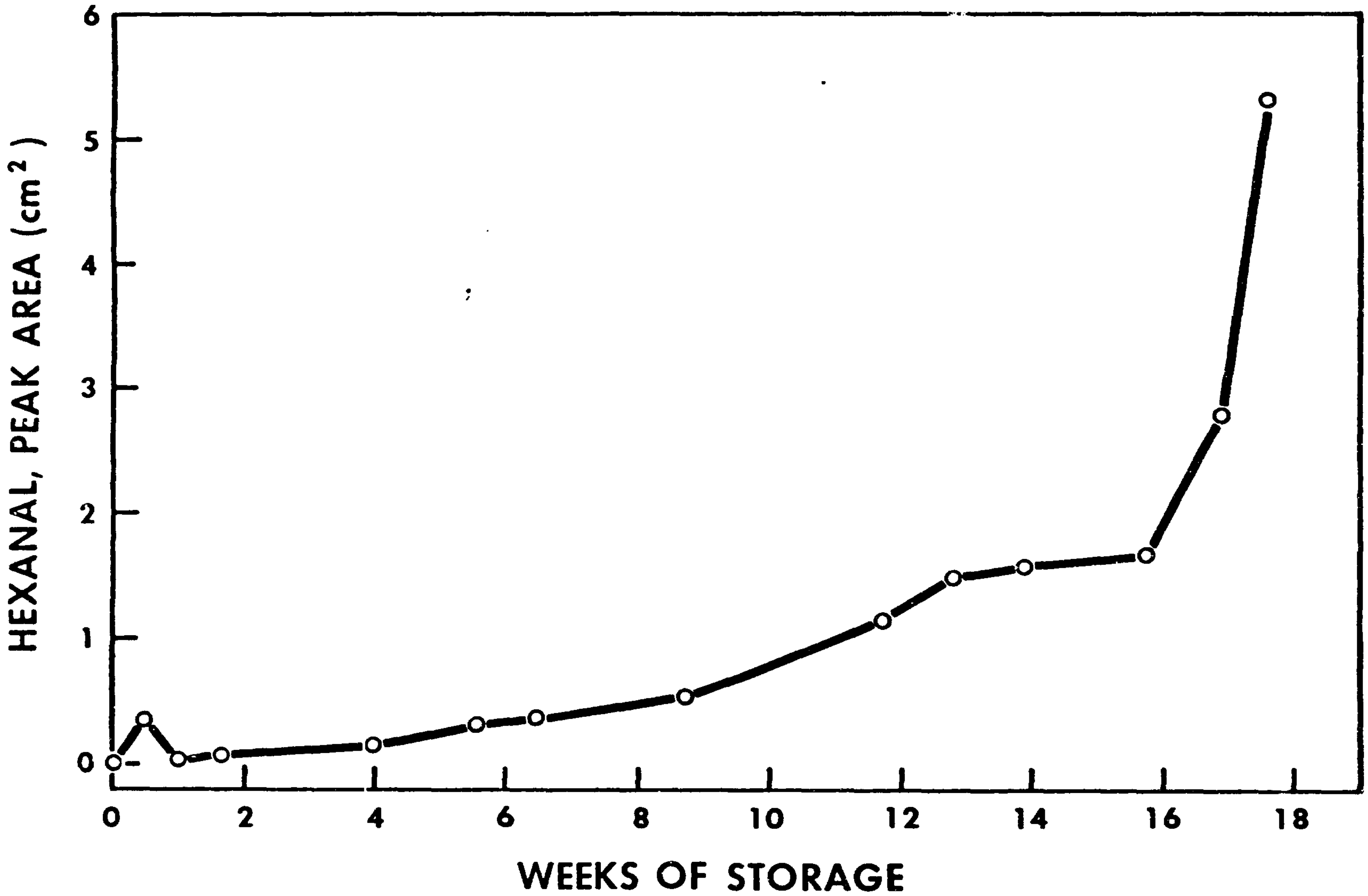

Figure 1.2 HEXANAL CONTENT OF HEADSPACE GAS FROM PUFFED GROUND BULGUR STORED AT 90° IN OXYGEN

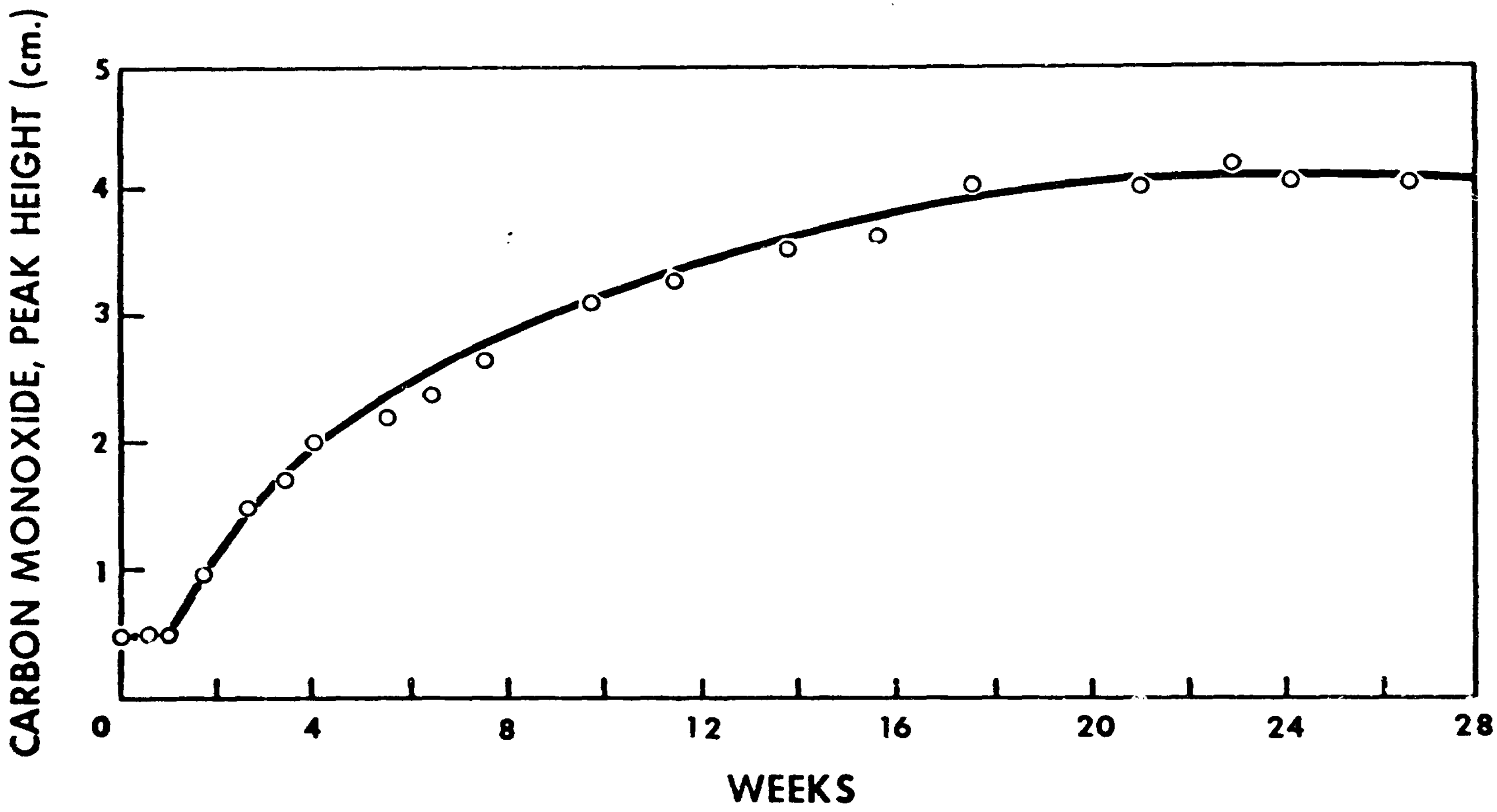

Figure 1.3 CARBON MONOXIDE, CONTENT OF HEADSPACE GAS FROM PUFFED GROUND BULGUR STORED AT 90° IN OXYGEN

wafer storage study at Oregon State University which are discussed in Section 2.

Pentane appeared in detectable amounts between the 11th and 12th week and continues to increase (Figure 1.4). Pentane content of the headspace gas may well be a useful test for surveillance, although further confirmation will be required to establish its validity.

Oxygen uptake of puffed Bulgur

It has been hypothesized that rancidity development is due to autoxidation of linoleic acid with the formation of hydroperoxides. According to this theory one mole of oxygen would be consumed per mole of fatty acid. Previously reported work (Bulgur Wafer and Adjuncts for Fallout Shelter Rations, FY 1965, p. 8) with methyl linoleate indicated this simple relationship did not hold and that secondary oxidation products formed also consume oxygen. This was confirmed by our prior research with similar tests on puffed bulgur.

The oxygen uptake experiment which attempted to correlate oxygen uptake by puffed bulgur and time of appearance of carbon dioxide, carbon monoxide, pentane, and hexanal was repeated. The conditions used were the same as those previously reported. The sample used in the current experiment showed no initial content of fixed gases, hydrocarbons, or aldehydes generally associated with oxidation. Further, the sample had a pleasing nutty-like odor, which is additional evidence that no oxidative changes had occurred.

The oxygen uptake-curve obtained in this work (Figure 1.5) differs from that previously obtained (typical unsaturated fat autoxidation curve). The curve showed no induction period and was linear within experimental error with oxygen consumption 4.3 ml per day without a subsequent leveling off. It appears that no simple relationship exists between linoleic acid content, oxygen consumption, and rancidity development.

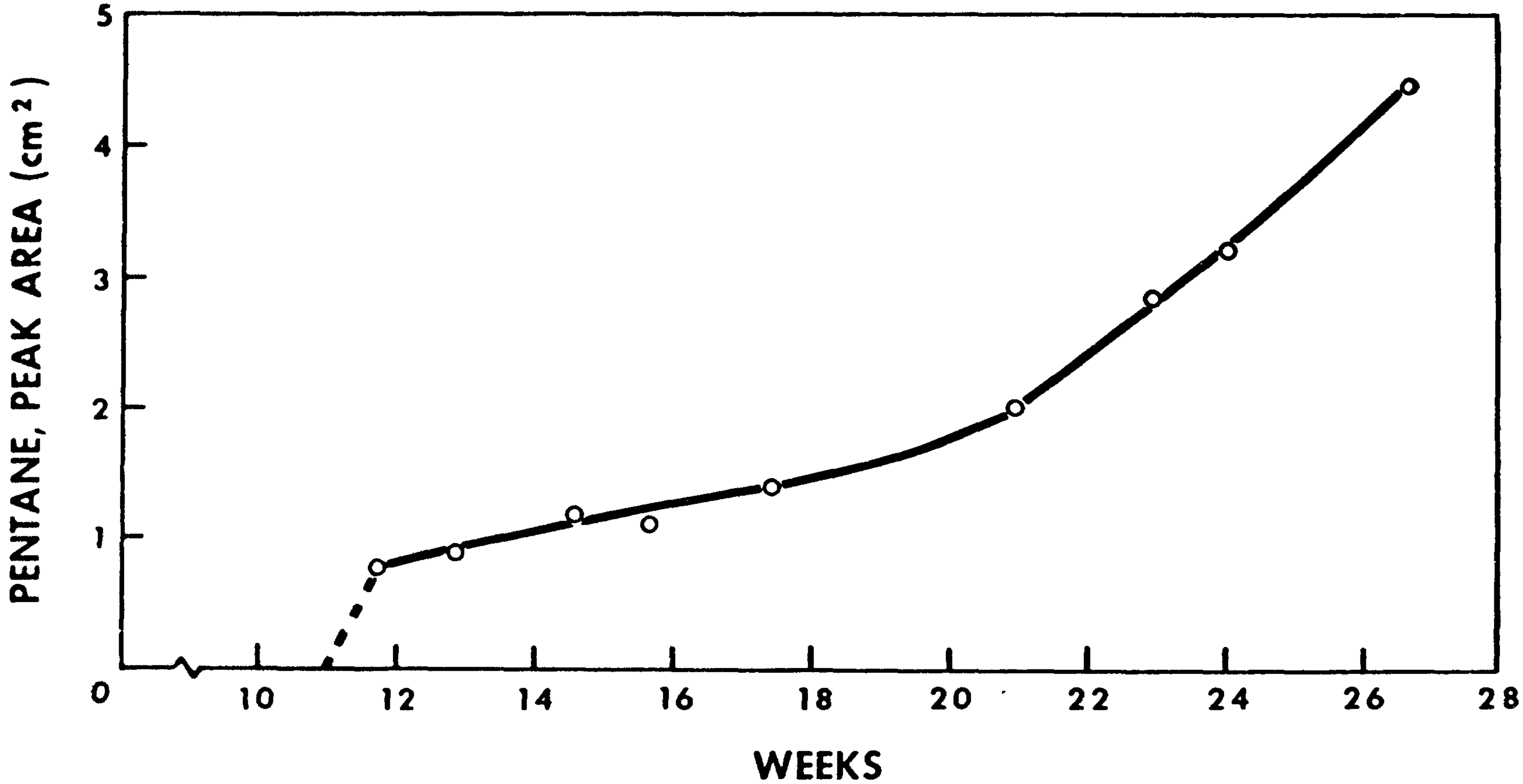

Figure 1.4 PENTANE CONTENT OF HEADSPACE GAS FROM PUFFED GROUND BULGUR STORED AT 90° IN OXYGEN

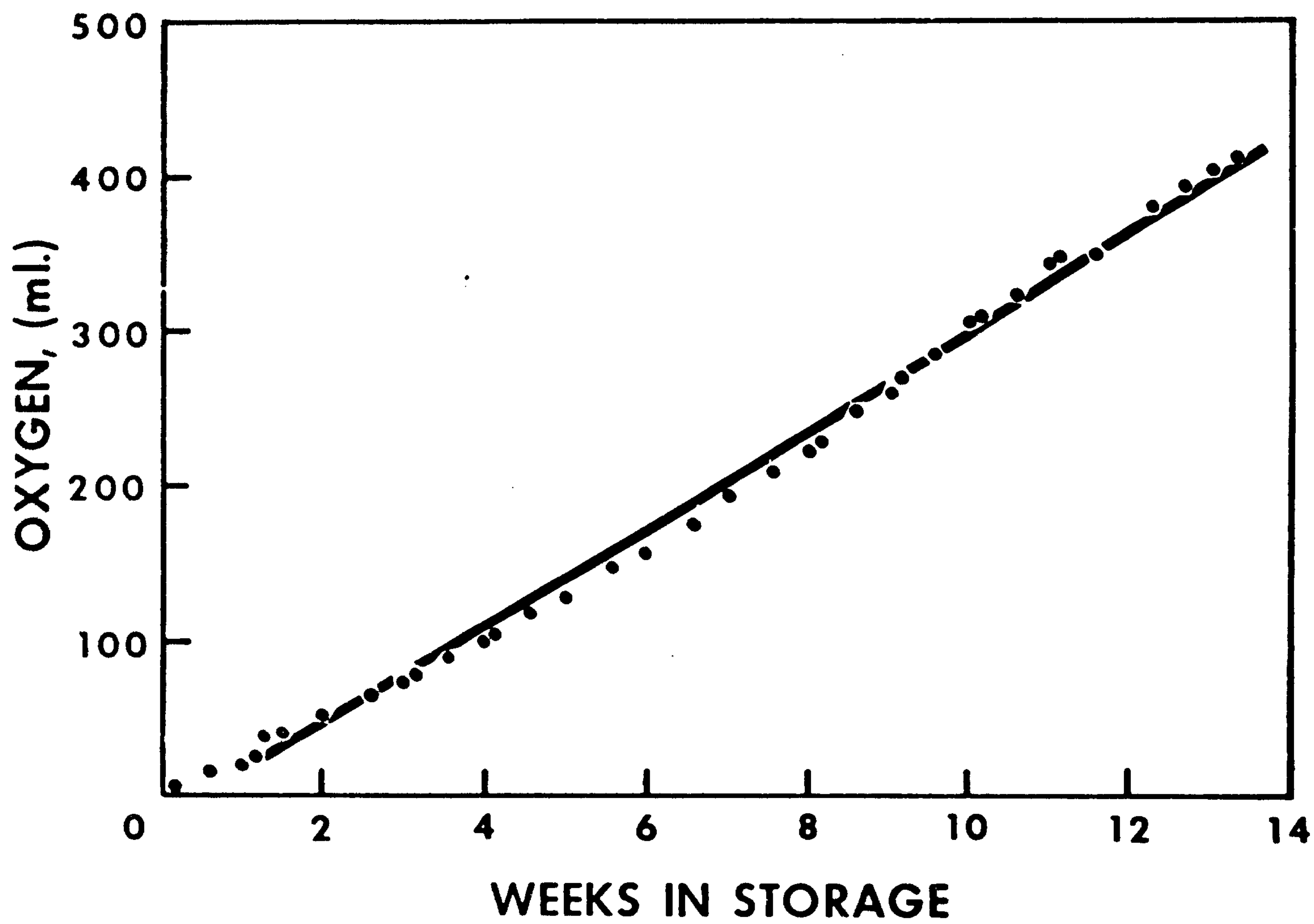

Figure 1.5 OXYGEN UPTAKE BY PUFFED GROUND BULGUR AT 100°F.

The growth curves for carbon dioxide, carbon monoxide, hexanal, and pentane were, within experimental error, the same as those previously reported (Bulgur Wafer and Adjuncts for Fallout Shelter Rations, FY 1966, pp. 8, 9).

SECTION 2
STORAGE STABILITY

The shelf life of shelter rations is a most important factor in determining the cost of any shelter stocking program. Taste-panel evaluation of quality changes of rations stored under conditions simulating those encountered during storage in warehouses and in the shelter standby period is a fundamental procedure for measuring shelf life. The validity of objective tests for surveillance requires establishing a useful correlation between such tests and the taste-panel evaluations.

Contracts with the Department of Food Science and Technology, Oregon State University, Corvallis, provide for 5-year studies on the storage stabilities of fallout shelter rations. A study of the stability of bulgur wafers commenced in 1962. A study of the stability of selected food adjuncts commenced in 1963.

Bulgur Wafers

The wafer storage stability study provides for evaluation of wafers representative of 8 different treatments prepared from each of two replicate lots of wheat (one red wheat, one white wheat). The treatments represent all combinations of the following formulation and packaging factors:

1. Bulgur - pressure cooked or atmospheric cooked,
2. Binder - malt sirup or corn sirup,
3. Package atmosphere - air or nitrogen

To provide the necessary samples, red and white wheats were provided by the Fisher Flouring Mills Co., Seattle, Washington. They processed part of each lot into bulgur by a pressure-cooking process. The remainder was processed into bulgur by atmospheric cooking at the Armeno Cereal Co., Westboro, Massachusetts. All bulgur was puffed and made into wafers by the Van Brode Milling Co., Inc., Clinton, Massachusetts.

The wafers are stored at three temperatures: 40°, 70°, and 100°F. Control samples are stored at 18°F. The wafers are sampled and evaluated at 6-month intervals.

Taste-panel evaluation

One formulation each of red and white wheat, those with pressure-cooked bulgur, malt sirup binder, and nitrogen pack were arbitrarily chosen to serve as reference and control samples. The flavor of control samples, which are held at -18°F, is scored at each sampling period by means of a 9-point hedonic scale ranging from 1 for the lowest to 9 for the highest rating. Results of these judgments through 52 months of storage are given in Table 2.1. At any given sampling time, no significant difference has been found between red and white wheat wafers and no trend has appeared with time. The variation in flavor scores as the test progresses appears to be only variation in taste-panel performance.

At each sampling period the reference formulations (defined above) stored at 40°, 70°, and 100°F are compared with their appropriate red or white wheat controls (stored at -18°F) by means of a reference-preference test on a 9-point scale. Results of these judgments through 52 months are given in Table 2.2.

Each of the other formulations is then compared, by means of the same kind of a reference-preference test, with its appropriate reference sample stored at the same temperature. Table 2.3 shows mean scores of the samples stored for 52 months and the original mean scores before storage.

The change of reference-preference score with time has been evaluated by statistical analysis. The slopes of the regression lines representing the linear relationship between reference-preference score and storage time and the correlation-coefficients have been

TABLE 2.1--Flavor scores[a] on 9-point hedonic scale[b] of bulgur wheat wafers--control samples made from pressure-cooked bulgur with malt sirup binder, packed with nitrogen and stored at -18°F

	Storage time, months									
	0	4	10	16	22	28	34	40	46	52
Red wheat	6.40	6.03	5.68	6.53	6.26	6.22	5.95	6.22	6.03	6.03
White wheat	5.72	6.41	5.82	6.42	6.20	6.39	6.02	6.29	6.11	6.22
	Overall average: 6.15									

[a] 160 judgments per sample.

[b] 9, like extremely; 8, like very much; 7, like moderately; 6, like slightly; 5, neither like nor dislike; 4, dislike slightly; 3, dislike moderately; 3, dislike very much; 1, dislike extremely.

TABLE 2.2.--Reference-preference scores[a] for flavor of reference samples stored at 40°, 70°, and 100°F

Averages[b] of data from both red and white wheat wafers

	Storage time, months								
	4	10	16	22	28	34	40	46	52
At 40°F	5.38	5.32	5.44	5.34	5.24	5.33	5.21	5.27	5.23
At 70°F	5.29	5.24	5.26	5.28	5.21	5.30	5.20	5.05	5.16
At 100°F	5.23	5.01	5.29	5.23	5.11	5.10	5.05	5.00	5.06

[a] 9, extremely better than control stored at -18°F; 8, very much better; 7, moderately better; 6, slightly better; 5, neither better nor worse than control; 4, slightly poorer than control; 3, moderately poorer; 2, very much poorer; 1, extremely poorer.

[b] 80 judgments per sample.

TABLE 2.3.--Reference-preference scores[a] for flavor of bulgur wafers, initially and after 52 months of storage

Averages[b] of data from both red and white wheat

Packaging	Binder	Initial scores		Stored 52 months at: 40°F		70°F		100°F	
		A[c]	P[c]	A	P	A	P	A	P
In nitrogen	Malt	5.57	5.27	5.38	5.18	5.55	5.71	5.61	5.49
	Corn	5.38	5.41	5.24	4.47	5.21	4.93	5.12	4.91
In air	Malt	5.44	5.35	5.18	4.91	4.04	4.17	4.72	4.88
	Corn	5.10	4.92	4.83	5.03	3.53	3.92	4.38	4.40

[a] 9, extremely better than reference; 8, very much better than reference; 7, moderately better than reference; 6, slightly better than reference; 5, neither better nor poorer than reference; 4, slightly poorer than reference; 3, moderately poorer than reference; 2, very much poorer than reference; 1, extremely poorer than reference.

[b] 80 judgments per sample.

[c] A = atmospheric-cooked bulgur; P = pressure-cooked bulgur.

calculated. The regression lines are shown in Figure 2.1. For matter of presentation reference-preference scores have been adjusted to correspond to the hedonic scores obtained for the control sample stored at -18°F. This has been done by assigning 6.15 (average of all control samples) as the zero time intercept on the hedonic score axis for all samples.

In Figure 2.1 the nitrogen-packed samples show a very slow decrease in flavor score (slope - 0.00328, correlation coefficient 0.54, significantly different from zero slope at 1% probability level). The slope for the nitrogen-packed samples is for all formulations <u>and for all test temperatures</u>. All air-packed samples stored at 40°F also show a very slow decrease in flavor score (slope - 0.00466, correlation coefficient, 0.64, significantly different from zero slope at 5% probability level).

The relationship between flavor score and storage time for air-packed samples stored at 70° and 100°F is obviously not linear. The crossing of the curves for these two storage temperatures was observed after about 34-months storage in last years' annual report and was questioned as to whether it was real or not. At each subsequent sampling period a slight preference has been shown for the samples stored at 100°F over those stored at 70°F. For the last three 6-month periods there has been little change in score for either of these samples. It appears that the samples stored in air at 100°F are slightly preferred to those at 70°F. The reason for this is not known.

Again these data make a very convincing case for using nitrogen packing for the bulgur wafer. Our data indicate that by nitrogen packing, one provides a product which, even at 100°F, does not differ significantly during storage from a product stored at 40°F if packed in air. Refrigerated storage would be too expensive for consideration but nitrogen packing may well be inexpensive enough. Some time ago Van Brode Milling Company roughly estimated an additional cost of 1 cent per pound for nitrogen packing. For a product costing 20 cents per pound, 1 cent per pound

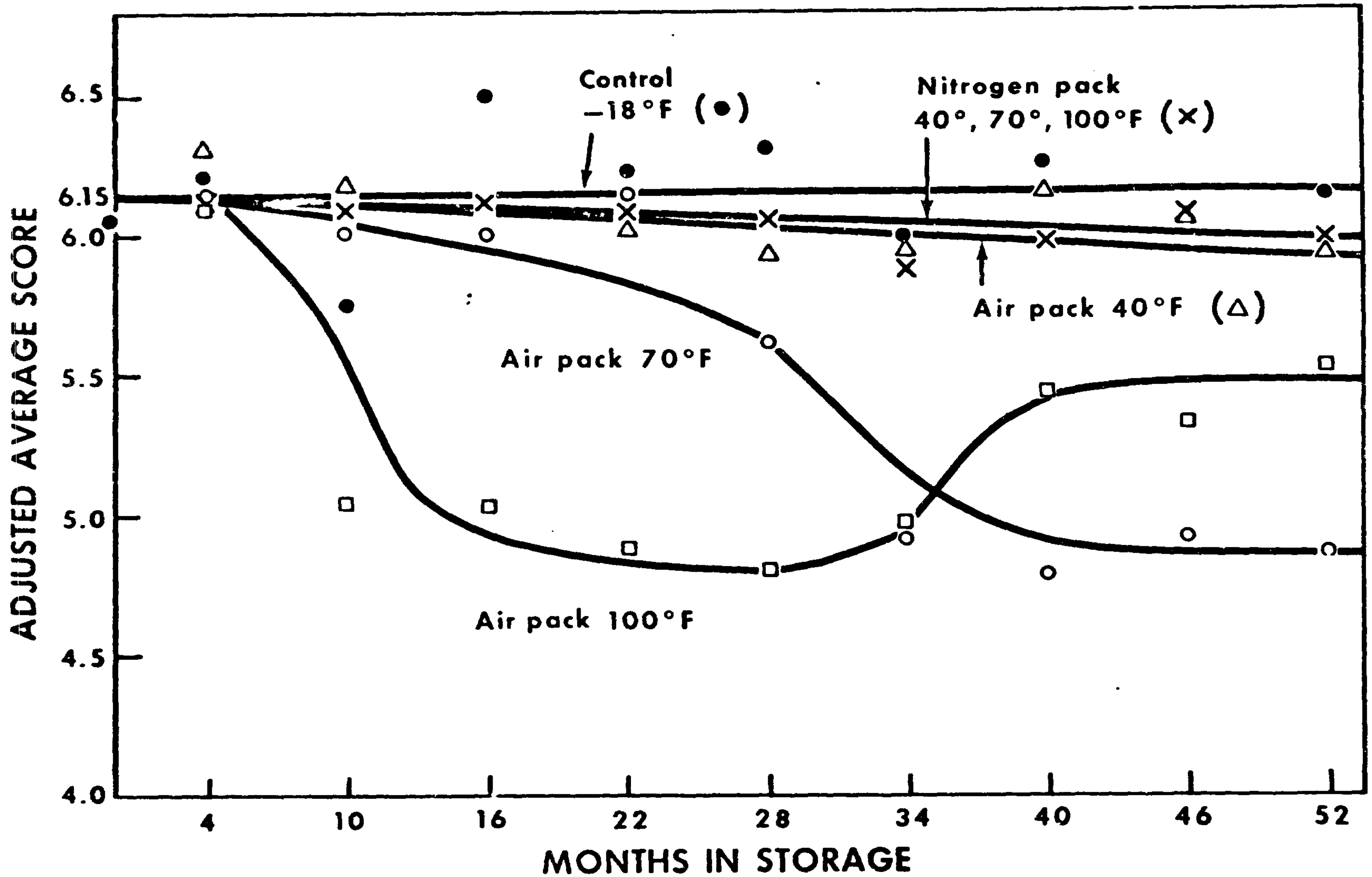

Figure 2.1 FLAVOR SCORE OF WAFERS AS INFLUENCED BY STORAGE TIME AND TEMPERATURE AND PACKAGE ATMOSPHERE

would represent a 5% cost increase which would be exactly balanced if shelf life were extended 5%. Based on results from the storage data, we would estimate an extension in shelf life many times 5% is possible. Furthermore, in the above reasoning, no allowance has been made for stocking or re-stocking costs. When these are considered the argument for use of nitrogen pack would become even more compelling. The binder (corn or malt sirup) and method of cooking (pressure or atmospheric) have less influence on flavor score than packaging atmosphere.

Chemical-physical determinations

At each sampling period, each lot of wafers is analyzed to determine percentage fat, peroxide number, thiobarbituric acid number, carbonyls, and diene values. Gas chromatograms (aromagrams) are also prepared. The contract was extended in June 1964 to include analysis of headspace gas for carbon dioxide, carbon monoxide, oxygen, and pentane.

Analyses have been completed on samples drawn from storage after 46 months. Changes are occurring in nearly all factors being studied. The changes are influenced to a varying degree by all the variables of interest. Temperature exerts the most consistent influence. However none of the tests specified in the original contract seem to correlate well with flavor score.

The headspace gas analyses, on the other hand, do show promise of being related to flavor score. This is particularly true for carbon-monoxide content of the headspace gas. Data for this constituent are shown in Table 2.4 for all storage periods since this test was started.

The data for air-packed samples only show a significant ($P<1\%$) correlation with flavor score: the slope of the regression line is -0.00449 and the correlation coefficient is -0.52. The regression line together with the 95% confidence limits for the line are shown in

TABLE 2.4.--Carbon monoxide content of headspace above bulgur wafers

(mean values for red and white wheat, peak area in mm^2)

Formulation[a]			Stored at 40°F months					Stored at 70°F months					Stored at 100°F months				
Cook	Binder	Pack	22	28	34	40	46	22	28	34	40	46	22	28	34	40	46
P	M	N	0	3	1	7	7	0	4	1	4	4	0	3	1	3	4
P	M	O	1	71	59	101	136	123	188	234	234	229	217	175	228	232	266
P	S	N	0	3	2	4	4	0	0	2	3	3	0	0	2	3	5
P	S	O	20	64	86	85	96	109	121	192	194	222	197	203	214	216	257
A	M	N	0	4	2	1	3	0	3	1	1	3	0	0	5	1	2
A	M	O	16	48	69	67	63	72	116	161	142	173	182	248	210	204	237
A	S	N	0	0	1	2	3	0	0	1	3	3	0	0	1	2	2
A	S	O	16	43	53	67	76	99	110	145	139	171	178	175	155	187	201

[a] Cook: P = pressure, A = atmospheric.

Binder: M = malt sirup, S = corn sirup.

Pack: N = nitrogen, O = air.

Figure 2.2. When the carbon monoxide data for all samples are included, the slope of the regression line is only slightly different, -0.00501, and the correlation coefficient is -0.69. The 95% confidence limits for this line are contained entirely within the limits shown for the regression line for air-packed samples only. So, in either case, carbon-monoxide content of the headspace gas seems to predict flavor score reasonably well.

Adjuncts

The contract to determine the stability of adjuncts in normal storage provides for taste-panel evaluation of twelve assorted supplements: apple topping, beef soup, butterscotch topping, chili sauce, chocolate pudding, cream of chicken soup, curry sauce, Oriental sauce, paprika gravy, raspberry jelly, strawberry spread, and wild cherry icing. Samples stored at 40°, 70° and 100°F are compared with nitrogen-packed controls at -18°F. All adjuncts are packed in tin cans, with nitrogen atmosphere in half of the samples and air in the other half. Five adjuncts low in moisture are packed without desiccants; the other seven, higher in moisture, have half the samples packed with in-package desiccant (IPD) and half without. All adjuncts are sampled at 6-month intervals. The experiment was discontinued at the end of FY 1967 after the 42-month evaluations were completed.

Taste-panel evaluation

At the beginning of the storage study and at each test period all samples have been evaluated before, during, and after preparation, by an expert panel of four judges. Odor, texture, color, and ease of preparation are scored on a 6-point hedonic scale (0-normal to 5-extremely off).

After samples had been stored 42 months, the expert panel gave only slightly altered scores on preparation, in most cases. The differences

were usually in the color of the dry mix or the rehydrated mix or both on samples stored at the higher temperatures. However, severe criticism (a score of 3 or higher) was given by the expert panel for certain attributes of some samples of apple topping, cream of chicken soup, Oriental sauce, paprika gravy, and raspberry jelly.

Samples of apple topping stored at 100°F both in nitrogen and air scored 3 on color because of darkening of the apple granules. Cream of chicken soup stored at 100°F without desiccant was scored 3 for nitrogen pack and 4 for air pack because of color of dry mix and color after preparation. Air-packed Oriental sauce at 100°F without desiccant was scored 3 on color of dry mix and color after rehydration. Paprika gravy samples at 70°F without desiccant in both air and nitrogen were scored 3 after preparation due to loss of color. Raspberry jelly samples at 100°F without desiccant in both air and nitrogen were scored 4 for dark color and 4 for texture (caking) in the dry mix. After rehydration those in nitrogen scored 3 on color and those in air 4 on texture (low jel strength).

Can corrosion as shown in Table 2.5 has become a potentially serious problem after 42 months of storage for certain adjuncts, notably chicken soup, Oriental sauce, and paprika gravy. For chicken soup, in-package desiccant shows a definite beneficial effect for samples stored at 100°F which is the only temperature where serious corrosion is observed. For Oriental sauce and paprika gravy there is no clear pattern; the cans are fairly generally affected regardless of temperature, packing gas, or with or without in-package desiccant. Ingredients common to all three of these adjuncts are chicken soup seasoning and pregelatinized tapioca starch. Tapioca starch is used in many of the other adjuncts which show little can corrosion so it is probably not the cause of corrosion. Therefore, chicken soup seasoning may be the responsible ingredient, although it is also an ingredient in the adjunct curry sauce, which does not show such severe can corrosion.

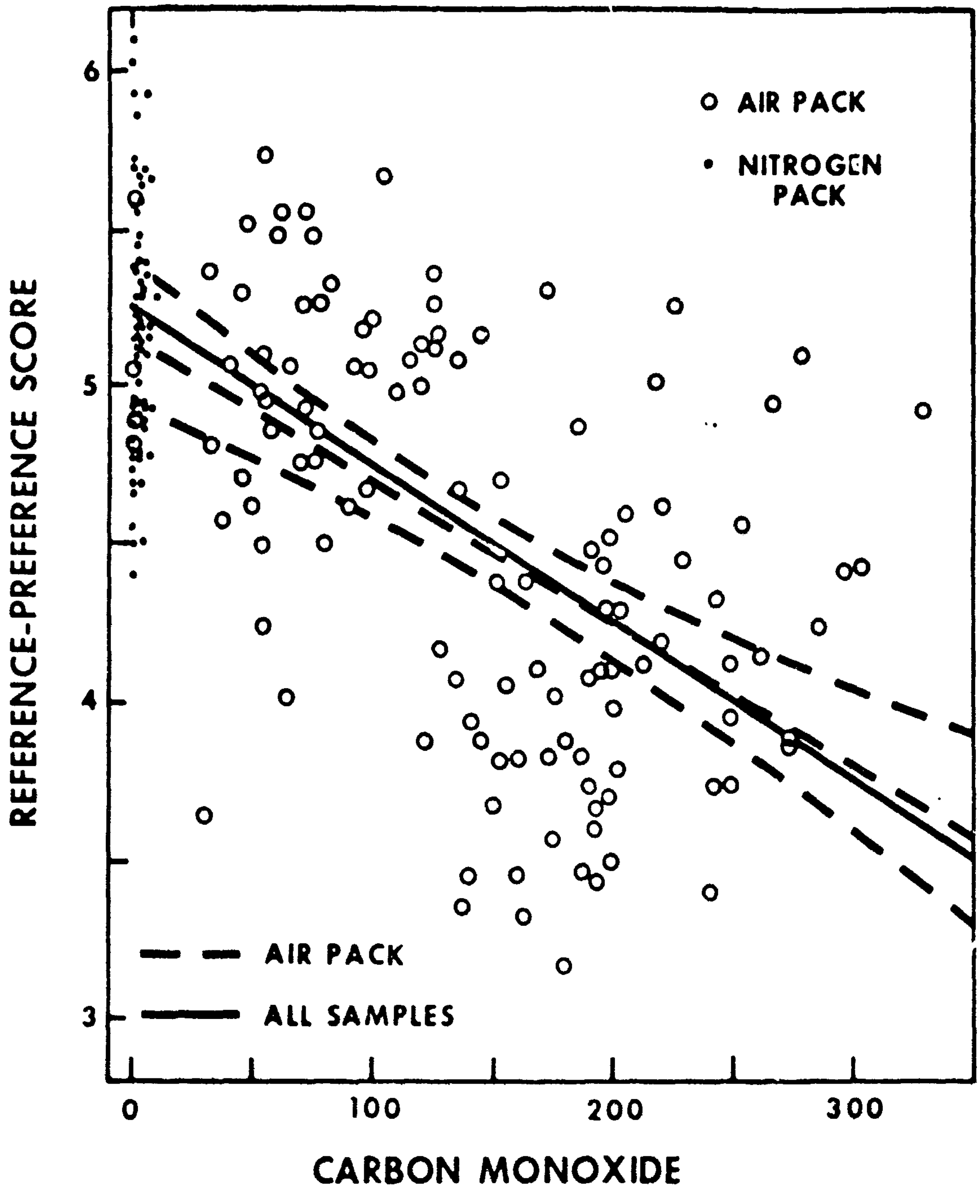

Figure 2.2 RELATIONSHIP BETWEEN CARBON MONOXIDE CONTENT OF HEADSPACE GAS AND REFERENCE-PREFERENCE SCORE

TABLE 2.5.--Can corrosion scores[a] after 42 months' storage

Storage Temperature °F	-18	-18	40	70	100	40	70	100	40	70	100	40	70	100
Packing Gas[b]	N	N	N	N	N	O	O	O	N	N	N	O	O	O
Adjunct IPD[c]	-	+	-	-	-	-	-	-	+	+	+	+	+	+
Apple topping	2		1	1	3	4	1	2						
Beef soup		1	2	2	e	2	3	e	1	2	1	1	1	1
Butterscotch topping	1		1	2	1	1	1	1						
Chicken soup		0	0	2	6	1	0	4	0	1	0	1	0	1
Chili sauce		1	1	1	1	2	0	0	1	1	1	1	1	3
Chocolate pudding[d]		0	0	1	0	1	1	1	1	0	1	0	0	1
Curry sauce		0	0	1	2	1	1	3	1	2	1	1	2	1
Oriental sauce		1	1	2	5	3	3	3	4	3	5	4	3	3
Paprika gravy		3	2	3	3	3	4	4	2	3	5	3	5	3
Raspberry jelly	1		1	1	1	1	3	3						
Strawberry spread	1		1	1	3	1	3	4						
Wild cherry icing[d]	1		1	1	0	1	0	1						

[a] 0 - no corrosion or detinning to 10 - very severe corrosion.

[b] N = nitrogen pack, O = air pack.

[c] +, with in-package desiccant; -, without.

[d] 36-month scores. Cans after 42 months discarded without scoring.

[e] Withdrawn from test after 6 months.

Evaluation of flavor by a large panel using a nine-point hedonic scale has been completed through 42 months. Mean flavor scores are given in Table 2.6 and 2.7. From analysis of variance based on all temperatures, the protective action of nitrogen packaging over air packaging is shown by the flavor scores for apple topping, raspberry jelly, curry sauce, Oriental sauce and paprika gravy. For all other adjuncts except strawberry spread considering all temperatures there is no significant difference. But for strawberry spread, samples with air packaging are preferred over those with nitrogen packaging. Some significant differences within temperatures are shown in Tables 2.6 and 2.7. Among the seven adjuncts for which IPD is a treatment variable, samples with IPD scored significantly higher for all except beef soup which showed no significant difference. The effects of high temperature are especially demonstrated by the lower flavor scores given apple topping, butterscotch topping, wild cherry icing, chicken soup, chili sauce, and paprika gravy stored at 100°F.

In general, flavor scores are staying up reasonably well for some combination of variables even at higher temperature storage. It may well be, therefore, that can corrosion or changes that reduce the ease of preparation would limit shelf life in many cases.

Chemical-physical determinations

On the samples possessing flow characteristics, Bostwick Consistometer readings are made in order to have objective measurement of changes in consistency during storage. Samples in which altered consistency was noted by the panel of expert judges, also had changes in Consistometer readings.

The headspace gas of all samples is being analyzed for carbon dioxide and oxygen. When appreciable oxygen is detected in nitrogen packs, the samples are rejected and new ones drawn. Carbon dioxide first appeared in headspace gas of a few samples after they had been stored for 6 months at high temperatures. In fact, both samples of beef soup

TABLE 2.6.--Flavor scores on 9-point hedonic scale for adjuncts packed without IPD, after 42 months' storage

		Storage temperature, °F				
Adjunct	Pack[a]	-18	40	70	100	LSD[d]
Apple topping	A		6.42	6.88	4.75	0.49
	N	6.70	6.42	6.60	5.95	
Butterscotch topping	A		6.15	6.30	5.25	0.46
	N	5.85	5.82	5.55	5.85	
Raspberry jelly	A		5.12	4.78	3.90	0.61
	N	4.62	4.45	5.90	5.00	
Strawberry spread	A		5 42	6.42	6.60	0.37
	N	5.62	5.48	5.70	5.92	
Wild cherry icing	A		6.28	6.82	5.82	0.43
	N	6.32	6.82	6.20	6.28	

[a] Packaging atmosphere: A = air, N = nitrogen.

[b] Least significant difference.

TABLE 2.7.--Flavor scores on 9-point hedonic scale for adjuncts packed without IPD, after 42 months' storage

			Storage temperature, °F				
Adjunct	IPD[a]	Pack[b]	-18	40	70	100	LSD[c]
Beef soup	0	A		5.80	5.85	d	
	0	N		6.00	5.96	d	
	+	A		6.31	6.02	5.55	
	+	N	6.22	6.05	6.47	5.85	
Chili sauce	0	A		5.14	4.83	4.37	
	0	N		5.02	5.29	4.50	0.57
	+	A		5.23	4.96	5.17	
	+	N	6.19	5.19	5.85	4.81	
Chocolate pudding	0	A		6.19	5.87	4.04	
	0	N		6.77	5.98	6.75	
	+	A		7.02	6.94	7.29	0.43
	+	N	6.33	6.89	7.33	6.87	
Cream of chicken soup	0	A		6.19	5.87	4.04	
	0	N		6.00	5.42	4.44	
	+	A		6.60	6.35	6.02	0.52
	+	N	6.31	6.69	6.31	5.83	
Curry sauce	0	A		4.48	4.52	4.48	
	0	N		4.69	5.27	5.27	
	+	A		5.08	5.35	5.60	0.55
	+	N	5.23	5.62	5.08	5.75	
Oriental sauce	0	A		4.21	5.04	4.42	
	0	N		5.02	5.19	4.33	
	+	A		4.29	5.29	5.35	0.53
	+	N	4.87	5.21	5.39	5.81	
Paprika gravy	0	A		5.62	4.19	3.25	
	0	N		4.98	5.50	3.42	
	+	A		4.71	4.23	4.94	0.57
	+	N	4.94	5.29	5.69	5.27	

[a] + = With in-package desiccant, 0 = without.

[b] Packaging atmosphere: A = air, N = nitrogen.

[c] Least significant difference.

[d] Withdrawn from test after 6 months.

stored at 100°F without IPD were hard-swells with very high carbon dioxide content at 6 months; they had to be removed from the test. Carbon dioxide has continued to increase in all samples stored at 100°F with no desiccant, up to the 42-month check. Air-packed samples consistently developed more carbon dioxide than did nitrogen packs. No samples with IPD show any carbon dioxide, because the desiccant absorbs it.

Beginning with the 24-month period, carbon monoxide content in the headspace gas has been measured. Carbon monoxide, for the most part, parallels carbon dioxide in the samples without IPD but has the advantage that, because it is not absorbed by the IPD, it can be measured in all samples. Data for carbon monoxide content at 42 months are given in Tables 2.8 and 2.9.

As observed for the wafers, adjunct samples packed under nitrogen show very low carbon-monoxide levels. The samples packed in air without desiccant, in general, show a higher level of carbon monoxide. Wild cherry icing to the contrary has shown no carbon monoxide in any sample and the carbon monoxide values in air for strawberry spread and raspberry jelly are very low except at 100°F. The presence of in-package desiccant substantially reduced the carbon monoxide level in all adjunct samples except chocolate pudding. However, even in this case some reduction in carbon monoxide is observed. In almost all cases, for air-packed samples without desiccant increasing storage temperature causes increased carbon monoxide content.

Reference to a company or product name does not imply approval or recommendation of the product by the U. S. Department of Agriculture to the exclusion of others that may be suitable.

TABLE 2.8.--Carbon monoxide content of headspace gas for adjuncts packed without IPD, after 42 months' storage (peak area in mm^2)

Adjunct	Pack[a]	Storage temperature, °F -18	40	70	100
Apple topping	A		4	21	224
	N	0	1	4	20
Butterscotch topping	A		3	14	125
	N	0	0	2	20
Raspberry jelly	A		0	3	60
	N	0	0	0	6
Strawberry spread	A		2	3	18
	N	0	0	0	3
Wild cherry icing	A		0	0	0
	N	0	0	0	0

[a] Packaging atmosphere: A = air, N = nitrogen.

TABLE 2.9.--Carbon monoxide content of headspace gas for adjuncts packed with and without IPD, after 42 months' storage (peak area in mm^2)

Adjunct	IPD[a]	Pack[b]	Storage temperature, °F -18	40	70	100
Beef soup	0	A		72	185	c
	0	N		3	5	c
	+	A		4	4	8
	+	N	0	0	0	4
Chili sauce	0	A		51	147	368
	0	N		2	4	4
	+	A		5	2	0
	+	N	0	0	0	1
Chocolate pudding	0	A		78	161	189
	0	N		5	12	10
	+	A		87	87	133
	+	N	0	6	8	7
Cream of chicken soup	0	A		8	27	380
	0	N		0	4	6
	+	A		4	6	15
	+	N	0	0	0	0
Curry sauce	0	A		30	84	201
	0	N		4	6	3
	+	A		2	0	0
	+	N	0	0	0	0
Oriental sauce	0	A		8	10	231
	0	N		0	5	51
	+	A		8	4	1
	+	N	0	0	0	0
Paprika gravy	0	A		22	55	320
	0	N		3	0	15
	+	A		15	15	6
	+	N	0	0	0	0

[a] + = With in-package desiccant, 0 = without.

[b] Packaging atmosphere: A = air, N = nitrogen.

[c] Withdrawn from test after 6 months.

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BULGUR WAFER AND ADJUNCTS FOR FALLOUT SHELTER RATIONS

UNCLASSIFIED - U.S. Department of Agriculture, ARS Western Regional Research and Development Laboratory November 1967, 30 pages, Work Order No. OCD-OS-62-54 Work Unit 1311A.

Abstract: Volatile products from lipid autoxidation in stored puffed bulgur were analyzed for components that may be useful indicators for surveillance testing. Taste panel evaluations indicate that storage stability of bulgur wafers under nitrogen is excellent. Flavor scores for adjuncts (sauces, spreads, etc) stored 42 months remain high, but can corrosion and preparation difficulties may limit storage life.

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13. ABSTRACT

Vapors from rancidifying bulgur are being analyzed for indicators that may be useful for surveillance testing of bulgur wafers. Nine previously unobserved components with rancid orders were characterized by a gas-liquid chromatographic technique in which peaks are smelled at the same time they are quantitated.

Storage stability results on bulgur wafers show a descernible, but inconsequential decrease in panel flavor score through 52 months for all samples packed in nitrogen, regardless of storage temperature (40°, 70°, and 100°F), and for those samples packed in air at 40°F. Other variables, binder and method of cooking, are relatively unimportant. Correlation between carbon monoxide content of the headspace gas and taste panel scores for all samples is significant at the 1% level. In general, flavor scores for adjuncts stored 42 months are remaining reasonably high for some combination of variables, even at higher temperatures. It now appears that in some cases, changes in the dry mixes that hamper their preparation for serving and corrosion of the containers may well limit the storage life.

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